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Perspectives

The energy transformation as a disruptive development at community level

Elisabeth Dütschke*, Julius P. Wesche

Fraunhofer Institute for Systems and Innovations Research ISI, Breslauer Str. 48, 76139 Karlsruhe, Germany

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ABSTRACT

Mankind is facing huge challenges due to climate change and subnational actors are increasingly considered to be relevant actors in the energy transition. In this paper, we argue that the municipal level will play a crucial role in a rapidly changing energy system and that the impact of this development can be labelled disruptive if we apply an adapted definition of the term disruptiveness that refers to system change. We illustrate this based on the example of implementing renewable district heating systems, which depend strongly on community support.

1. Introduction

The challenges mankind faces in the wake of climate change are huge, and although still heavily debated and in spite of frequent drawbacks, many steps are being taken to move along a governed transition towards more sustainability. The Paris agreement represents an important stepping-stone in this process. However, if this transition is to be successful, multiple parties and societal actors need to act in concert. This includes moving the focus to the community level as well [1,2].

2. Why are communities important?

The literature on the transition of the energy system and climate change has addressed several societal groups, and policy makers are among the more frequently mentioned ones [3–5]. Much of the literature refers either to the overarching levels of governance, i.e. the supranational, transnational or national level, or to the levels of individuals, i.e. households and citizens.

This is not surprising given that high-level policy makers have the task (and in democratic societies also the mandate) to provide strategy and set framework conditions, while citizens provide them with the legitimacy to do so via elections (again: in democratic societies). Ultimately, however, it is the citizens' actions as private individuals or in professional or other roles within these frameworks that influence whether the set targets are achieved or not. Of course, it is important to acknowledge that individual agency is limited by the social structure made up of families, friends, colleagues and the restrictions of daily life – all of which takes place at local level. This micro level social structure is supported and limited by material structures like (physical) local infrastructures as well as societal level structures like culture and social rules as well as resources, power structures and the need for appropriate opportunities. However, much of this is reproduced and shaped and therefore also changed at the local, community level. In this paper, we explore the community level and its role in the energy transition in more depth. When we talk about communities, we are referring to the municipal level in the policy system. However, we regard municipalities as more than just administrative or structural entities. Therefore, we use the term community to signify that we regard this as a socially constructed entity that includes formal roles but is – like individual agency – shaped by physical infrastructure, social and cultural rules and the customs followed by its inhabitants as well as its location in a specific geographical place.

Seen from the angle of policy making, major decisions are taken at national or – depending on the constitutional structure – at subnational level, e.g. the German Bundesländer or state level in the US. Despite this, a major part of the actual implementation of these decisions as well as managing compliance is realised at community level [2]: This is where houses are built, companies founded, energy consumed, heat and electricity generated etc. Usually all of these require communal planning, administrative processes and local action. Thus, communities can be regarded as important structural hinges between higher level policies and individual actions. But what role do they play in the energy transition and to what extent is this linked with disruptive innovation at community level? We take the opportunity this perspective offers to explore answers to these questions and link our arguments to a recent case study of renewable district heating. This case study and the other examples in this paper mainly refer to Germany given the research focus of the authors and the background of the German Energiewende, which can be seen as an example for a possible pathway for energy transition.

The term 'Energiewende' refers to the political decision in Germany

* Corresponding author.
E-mail address: elisabeth.duetschke@isi.fraunhofer.de (E. Dütschke).

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to phase out nuclear energy by 2022 [6] and to aim for ambitious goals regarding renewable energies. A comprehensive policy mix has been implemented to achieve the target of 80% of electricity generated from renewable energies by 2050 [7,8]. By the end of 2015, renewables had reached a share of 31.6% in Germany's electricity generation and the country is on track to meet its interim target of 35% by 2020. A similar development has taken place in the heat sector, where a share of 13.2% renewable heat was achieved in 2015, approaching the target of 14% in 2020 [9].

3. What is disruptive innovation?

The concept of disruptive innovation was first developed in the field of business administration and has been widely used since, often drawing on the seminal work by Christensen. Christensen et al. developed the concept to describe how newcomers to a market may win shares from well-established incumbents by applying a specific market strategy that targets segments overlooked by the incumbents and allows them to gain a foothold by providing more suitable functionality [10]. Related to this aspect of more suitable functionality is an understanding of disruptive innovation that places the idea of novel user attributes at the heart of the definition [11]. A broader view that does not focus on the product, service or business model itself is discussed in the literature by contrasting incremental and disruptive or radical innovations [12]. It is assumed that disruptive innovations significantly alter the relevant market by changing the activities of market actors, e.g. when a new market structure emerges or even a new market develops, possibly replacing the previous one.

This perspective has also become relevant in the field of energy research in the wake of the huge challenges posed by climate change due to the assumption that disruptive (technological) innovations might be a solution to overcome these challenges while preserving a high standard of living. Here, disruptive innovation implies the emergence of products and services as well as new market structures that enable households and organisations to maintain a high level of mobility and energy-consuming services without loss of utility [13].

This has led to concepts which propose a modification of services such as using instead of owning, e.g. in car sharing schemes, where users keep the flexibility of driving a car while reducing the car's negative impacts because such schemes require a lower number of vehicles to be produced and maintained. Car sharing is often regarded as disruptive to the automobile industry because it moves people away from car ownership, relates costs more closely to actual usage as well as potentially reducing them for the individual user and may even – under certain framework conditions – increase individual flexibility since vehicle size can be adjusted to the requirements of a particular trip.

4. Is the energy transition disruptive at community level?

This perspective of disruptive products and services leads us to the question of the disruptiveness of the energy transition for communities. The energy transition from a policy perspective mostly refers to the challenge of how to generate and consume energy in ways that are less carbon-intensive, i.e. more sustainable, but that are also affordable for all members of society and ensure energy security (cf. [8]). This is, known as the energy trilemma according to the World Energy Council or the norm triangle of energy policy [14]. The product at the heart of this transition is energy, i.e. mainly electricity and heat for the purpose of this paper, and the services related to them, i.e. heating, cooling, powering appliances, lighting etc. The question we would like to examine here is whether or not it is likely that the energy transition will lead to disruptive developments at community level.

Schönberger and Reiche [15] identify five fields of opportunities for sub-national actors like municipalities in the energy transition: as consumers, as regulators and planners, as energy providers, as providers of information and support, and finally engaging in overarching measures like strategic plans. In the following, we discuss these five fields and analyse possible implications for them from the energy transition.

On the *consumption* side, it is not yet clear what changes the energy transition will lead to for community as a consumer. It is likely that services providing heat for heating systems or hot water will hardly change at all. Greater changes might be related to consuming electricity, especially if a closer link between consumption and generation is actually implemented through concepts of prosuming or demand-side management that ask consumers to flexibly shift loads, i.e. adapt their behaviour, or install smart grid technologies at their properties. Of course, it is possible that these concepts will be rolled out to certain consumer groups only, like households or industry. However, most likely, this will also include public buildings like schools or swimming pools, municipal services and administration. This also implies investments in the relevant (smart) technologies at community level. However, the changes arising in this field for communities are not expected to be significantly different to the implications for households or companies even if the transition to demand-side management becomes the dominant pathway. Nevertheless, it is possible that pressure will arise from higher political levels or from local citizens or companies asking the municipality to act as a role model in this area. To sum up, consumption is not a field where we expect disruptive transition for communities.

As a consequence of the energy transition, a higher level of disruption is expected in the field of energy generation as well as in processes and among actors involved in energy generation. While many questions are still open, the overall trend shaping the energy transition means moving away from a highly centralised, clearly structured system towards a more decentralised, more fluctuating energy system due to the high shares of renewables. This is related to communities' roles as *municipal regulators and planners*, as *energy providers* through both municipal companies as well as community (=citizen) owned facilities and finally as *providers of information and support*.

Generally, the roles in the energy system are less clearly defined in this new system and start to blur, e.g. when traditional consumers of energy also start generating it. To smooth and accelerate the transition at local level, communities could become important intermediaries in developing such a complex system of energy providers. On the one hand, it is expected that this will be shaped by the new parties who generate electricity, e.g. from PV or micro combined heat and power units, partially consume this themselves, partially feed it into the grid, and partially still rely on supply from the grid. On the other hand, for a very long time or even indefinitely, this system will also rely on more conventional actors, i.e. big power plants producing energy and relevant shares of properties that only consume energy. It is probably most effective to (also) coordinate, strategically plan, implement and manage this system including its heterogeneous actors at municipal level, where these different actors need to be harmonised in order to maintain energy supply security and where installations are set up. This will also be illustrated in the example below when we expand on renewable district heating in Germany.

It is also likely that this system will be financed through a similarly complex system involving new investors, e.g. households installing their own PV system or investing in (local) wind farms; organisations running cogeneration units or offering waste heat for district heating. Again, it is not necessarily expected that these new types of investors will fully replace the more traditional investments of financing institutions or energy companies, but in Germany, for example, almost half of the owners of windfarms are private individuals [16]. As for the management of the supply side, this points to a more heterogeneous system of actors and to the potentially important role of communities as intermediaries who facilitate networks between relevant individuals and groups or govern these initiatives towards a harmonious local system. In addition to this, communities may become more important as investors themselves, usually via companies/utilities owned by the

communities. Palm and Fallde [17] describe an example for this based on a case study in Linköping. They outline how the local energy company tried to anticipate the strategy of the municipality in energy terms and adapted its business to match it.

What is apparent in all the changes described so far is the increasing level of complexity, with a higher number of more heterogeneous actors needing to interact. This heterogeneity also includes heterogeneous levels of knowledge and expertise, familiarity with processes etc. Again, this emphasizes the role of community representatives in creating networks of relevant actors, supporting them in following certain procedures, e.g. from an administrative point of view, distributing relevant information as well as informally or formally coordinating different initiatives. This last issue is connected to a new need for communities to think about energy more strategically by including it in all community-based planning processes and also by identifying possible synergies or contradictions. These include, e.g. implications for the distribution network if electricity generating infrastructure is set up, predicting energy demand in highly efficient buildings, creating a stable supply of renewable district heating. This means that energy becomes a strategic issue in community planning. Such strategic approaches are mirrored by the high number of goal setting documents, local energy concepts/guidelines and climate/energy action plans [15]. More specifically, the requirements outlined so far imply the development of new competencies for community representatives like mayors and council members but also municipal administrations and municipal companies. A higher level of energy knowledge will be required as will networking abilities and strategic thinking in a new field. Overall, it implies an enlargement of the traditional municipal role where communities were more of an executor in the implementation of energy provision and governances mostly included bureaucratic processes like authorizing permits. We assume that this enlargement is not purely incremental, but disruptive as it will involve new types of actors in the local energy system, create new networks between actors, require increased knowledge of energy system planning and management and change governance structures.

5. Renewable district heating as an example

In a recent research project (www.transnik.de), we looked at the field of renewable district heating as a sustainability niche at community level where several projects have been implemented lately, many of them in rural areas. The heating market in Germany has been dominated by single-building gas and oil boilers [18], which are mostly supplied by domestic industrial actors. These products are engineered to be more efficient and feature an increasing number of smart characteristics. The majority of local installers have exclusive contracts with one of these industrial actors. Some of these industrial actors have recently acquired companies with technological knowledge about new and more sustainable heating infrastructure [19]. However, they tend to remain on their current trajectory based mainly on incremental innovations to their products, because of high profit margins and the high investments made in the past.

Two strategies are possible to make heating homes and other properties more sustainable: Either the buildings themselves are made more efficient by better insulation or the heat required is generated in a more sustainable way. Renewable district heating is a strategy for the latter course. First, it brings the well-known advantages of district heating where several properties share a heat source and are connected by a heat infrastructure which is more efficient to operate than individual systems [20,21]. Second, the heat used by renewable district heating is less CO_2-intensive since it is either supplied by renewable sources like solar, biogas and biomass or as waste heat from industrial or agricultural processes [21,22]. This means that local and/or renewable energy resources are used, establishing a new market structure involving new actors like local farmers or industry as heat providers.

More sustainable district heating concepts can either be implemented in newly built districts or in existing ones where they replace the previously used conventional fuels such as natural gas or oil. Currently, the district heating sector is expanding at a low rate. However, German policy makers are increasingly recognizing the fact that heating networks could play a major role for the heating transition by cutting CO_2 emissions. Therefore, they have recently been identified as a key instrument for the heating sector in the climate action plan issued by the German federal government [23] and it is planned to expand the R & D funds for advanced district heating systems [24].

If such innovative district heating systems are implemented, the heat is sometimes supplied by traditional stakeholders, such as local utilities. In other places, new stakeholders become involved as energy providers, e.g. when a local manufacturing company offers waste heat, farmers provide biogas or private project developers start to install new networks and run them as contractors. Shared heating systems can only be advantageous, in economic terms as well, if the number of participating properties is high enough and situated close enough to each other to reach a satisfactory heat density. Thus, either the municipality has to prescribe participation – or enough property owners have to be convinced to join the scheme. It is very difficult to prescribe participation as some of the details how to do this compatible with law are not fully clear. Furthermore, local decision makers are sometimes reluctant to push ahead with such schemes, because they fear their municipality will be perceived as less attractive than neighbouring ones.

What we found by analysing six cases of successful implementation across Germany is that the role of the community and municipal actors is crucial. Successful district heating systems usually draw on the support of municipal actors or important opinion leaders from the relevant community. These persons' involvement is needed to initiate the process, convince property owners, identify potential heat providers, but often also to plan and build the relevant infrastructure. Seen from our findings in our case studies it seems only possible to successfully manage the implementation process if municipal stakeholders become closely involved, join the relevant actor networks and acquire the necessary expertise. In most of the analysed cases, we found that integrating publicly owned buildings and facilities (such as town halls and schools) increases the likelihood of successful implementation because this guarantees a substantial base load and functions as a confidence building role model for private consumers. Additionally, deciding on a heat source and actually establishing it is also a process on community level. Thus, setting up a renewable district heating system involves the community as a consumer, as a regulator and planner, concerns the field of energy generation and is dependent on support, knowledge exchange and networks.

To what extent does this imply a disruptive development for the community? From a market perspective, implementing district heating is a major change for the local heating market, where several market actors like heating system installers or chimney sweeps become less relevant. From the point of view of property owners, district heating reduces their autonomy and binds them to a new, shared system. This is not different from conventional district heating which is, however, not very common in Germany outside bigger cities. The major disruption is related to the heat production. While conventional systems run on fossil fuels that are typically imported, the innovative district heating systems run on locally provided heat and fuels.

6. Conclusion: the energy transition as a disruptive development at community level

We argue that the energy transition can imply disruptive change at community level. The disruptiveness we identify is different to a product- and market-based understanding of disruptiveness [10] and more closely related to a definition that sees disruption manifest itself in new functionalities and system change. In our case, this means we also take into account the supply and distribution side of energy as a product or service.

It is important to realise that we are not trying to argue that communities are driving the energy transition – even though individual large communities like big cities may have the opportunity to play an influential role [25], the literature suggests this is not the case for smaller communities [26]. But we are taking the reverse angle by arguing that the energy transition as a broader, transnational, maybe even global process is manifesting itself, if successful, in a disruptive way at community level. It may be possible that an energy transition could also be implemented by decarbonisation based on highly centralised systems, e.g. replacing conventional power plants mainly by offshore wind. However, when looking at current developments as well as the factors that feed societal support for the energy transition, a decentralised system seems to be more promising. As we have tried to argue in this paper, such a transition involves the municipal level and its actors to a much greater extent than before and is likely to reshape the municipal energy system in such a way that it will be disruptive.

We would expect even higher levels of disruptiveness when looking at sustainability transition in general, e.g. involving areas like housing, transport or water management as these have an even stronger influence on how the configurations of living and working together are organised at community level.

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